Implications of New Insight into the Genetic Structure of *Theobroma cacao* L. for Breeding Strategies

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Abstract

The genetic diversity of cocoa has been studied using morphological, enzymatic and molecular descriptors. It has often proved difficult to obtain a clear classification due to factors including the significant genetic mixing that has occurred over the past three centuries, bias in the samples analysed (*e.g.* the limited number of Forastero samples collected in Peru for Witches' broom resistance), the uncertain origin of some accessions (*e.g.* some early studies were based on material believed to be Criollo, but which was in fact of hybrid origin), different populations have been used in different studies. Breeding has been hampered by a lack of knowledge of the genetic diversity and level of heterozygosity of the accessions.

The main results of the diversity studies are:

- In Forastero populations there is significant diversity between and within populations, with continuous variation between them. The greatest diversity was observed among Ecuadorian LCTEEN populations, and the least among a few populations such as Peruvian NA or GU from French Guiana. However, the Ecuadorian populations studied by Allen were collected from a larger number of trees and from a wider area than those collected by Pound, and very few Colombian and Brazilian samples were used in these studies.
- Almost completely homozygous "ancestral" Criollo and Nacional genotypes that were probably at the origin of "modern" Criollo and Nacional varieties were identified. Modern Criollo and Nacional varieties are hybrid types resulting from introgression of a few Lower Amazon Forastero genotypes into ancestral Criollo, and of Trinitario into ancestral Nacional varieties, respectively.
- The specificity of some populations or varieties has been recognised, for example wild French Guiana, ancient Criollo and Nacional varieties. The founder effect or refuge areas may be responsible for the differences between these populations.
- The narrow genetic base of cocoa genotypes used in breeding programs is well known.
- The level of heterozygosity of several hundreds of clones has recently been established (data presented here) and this new information may be very useful to breeders.

Many breeding programmes have only used a limited number of Upper Amazon Forastero types collected by Pound. Genotypes from other populations have been used very little or not at all (*e.g.* wild French Guiana, LCT EEN, Colombian EBC types, etc). It would be particularly interesting to set up prospective trials of crosses between genotypes from these different populations. This would exploit the diversity of natural *T. cacao* populations that have not previously been used and may result in new heterotic combinations. Secondly, the genetic diversity studies have given useful information for population breeding approaches, such as reciprocal recurrent selection. Thirdly, the narrow genetic basis used in many cocoa breeding programmes to date is favourable for the exploitation of the expected linkage disequilibria within such populations. QTL mapping is generally done on a few specific progenies, and the results only relate to the clones involved. It is possible to enlarge such studies to analyse the degree to which genetic linkage between markers and traits of interest has been maintained during the evolution and domestication processes in genetic groups such as IMC, SCA and MO, Forastero, Criollo, Trinitario or Nacional.

Introduction

A few reminders on the history of cocoa

Cocoa was domesticated thousands of years ago by the Mayas and Aztecs (Paradis 1979). Even before the Spanish conquest, cocoa travelled along the trade routes used by the Mayas, Aztecs, and also the Pipil-Nicaraos (Young 1994; Coe and Coe 1996). Criollo types then spread to Central America, and to a large number of Caribbean islands, including Trinidad in 1525 and thereafter to Jamaica. Cocoa introductions into Venezuela from Central America, particularly Costa Rica, were made by the Spanish (Pittier 1933), but it is also possible that cocoa may have been grown before the Spanish Conquest in the south-west of the country (Pittier 1933; Bergman 1969). The French planted cocoa in Martinique and Haiti, and the Portuguese planted it in Belem and Bahia around 1750, using Lower Amazon (Forastero) populations.

Hybridisations between Criollo and Forastero types in the 18th Century resulted in Trinitario types. It is not well known how this hybrid group initially formed. According to Pound (1945), the two populations could have met and hybridised on the islands of the Orinoco delta, including Trinidad and the Orinoco valley. This could have involved the cultivated Criollo population from Venezuela and the Amelonado type Forastero from Guyana, and was probably linked to exchanges between Venezuela and Trinidad. Cheesman (1944) reported that, in 1727, the "Blast", perhaps a cyclone or an epidemic, destroyed the Criollo plantations in Trinidad. Plantations were reconstituted using seeds from the Orinoco valley, in Eastern Venezuela (Ciudad Bolivar). According to Cheesman, there is still some doubt as to the nature of these introductions, which may have been either Amelonado type Forastero, or already hybrid Trinitario forms. Other varieties, such as those grown on the Venezuelan coast, may also have been introduced (Bartley, pers. comm.). Hybrids were produced by open pollination, and their superiority in agronomic terms and better resistance to diseases and pests favoured their use in Trinidad as a replacement for Criollo types. Trinitario material was distributed from Trinidad 70 years later, particularly into Venezuela.

According to Bartley (pers. comm.), the formation of hybrid populations following the introduction of Forastero types into original Criollo plantations may correspond to four main waves of introductions, possibly involving different genotypes. In addition to the introductions described above between Trinidad and Venezuela, there may also have been introductions of Ecuadorian cocoa into Mexico, introductions of varieties grown at the mouth of the Amazon into Central America, and of Amazon varieties into Colombian Criollo plantations in the 19th Century.

Selections were made in Trinidad among the Trinitario population and large numbers of clones (ICS, for Imperial College Selection) were distributed world-wide. The current plantations in Central America and Venezuela, which are very heterogeneous, often comprise a population of hybrids of varying degrees of introgression between Forastero and Criollo. The terms Criollo and Forastero originally came from Venezuela, where a distinction was made between traditionally grown local varieties (Criollo) and foreign trees (Forastero) introduced later from Trinidad, which were also known as Trinitario referring to the country from which they were introduced.

The Ecuadorian Nacional cocoa became an important variety in the second half of the 19th Century following the increase in cocoa consumption. According to Pound (1945), the "Nacional" type is probably indigenous to Eastern Ecuador. He refers to the existence of groups of very old wild cocoa trees resembling the Nacional type, known as "amacigales", in primary forest areas cleared for new crops. Nacional cocoa differed from the wild cocoa trees found in the Amazon Valley. Some Nacional traits have more resemblance to Criollo than Forastero types, but Nacional also has characteristics that distinguish it from both groups. One such characteristic is that Nacional cocoa has the specific 'Arriba' flavour (Enríquez 1993). Venezuelan cocoa types were introduced into Ecuador around 1890, via a few pods from Trinidad, where they had been introduced previously (Pound 1945). This material was particularly vigorous and precocious, even on poor soils, and most planters took seedlings from these trees to add to their original Nacional plantings. As a result, there was significant genetic mixing between the different origins, and pure types gradually disappeared (Soria 1970 a and b).

Cocoa was introduced into Africa more recently. It was first brought by Spanish or Portuguese seafarers, to São Tomé in 1822 and Fernando Po in 1855 (Burle 1952). Swiss missionaries then made other introductions, from Suriname, and the first cocoa seeds were sown on the African mainland in 1857. The first material planted in West Africa, particularly Ghana, was Lower Amazon (Amelonado) type but this was followed by introductions of hybrid Trinitario and Criollo types from 1920 (Toxopeus 1972) which formed hybrids with original Amelonado type. However, each introduction comprised only a very limited number of genotypes, and the genetic basis of the cocoa populations initially grown in West Africa was very narrow. Moreover, the origin of the material is unclear.

Cocoa was introduced in the 16th century into Asia and the Pacific (Wood 1991; Young 1994). In 1560, Venezuelan Criollo trees were introduced into Celebes by the Dutch, who later also introduced this type into Java. In addition, the Spanish introduced Criollo types from Mexico into the Philippines in 1614. In 1798, cocoa was taken by the British to Madras, India from the island of Amboina, and it was introduced into Ceylon (now Sri Lanka) from Trinidad at about the same time. From Ceylon, cocoa was subsequently transferred to Singapore and Fiji (1880), Samoa (1883), Queensland (1886), and Bombay and Zanzibar (1887). Cocoa was also grown in Malaysia as early as in 1778 and in Hawai by 1831.

Classification of cocoa

The species *Theobroma cacao* (2n = 2x = 20) comprises a large number of highly morphologically variable populations, which can all be crossed with each other. Populations may be mostly autogamous or allogamous, depending on their genetic origin. A system of gametophytic-sporophytic self-incompatibility studied by several authors (Knight and Rogers 1955; Bouharmont 1960; Cope 1962; Glendinning 1962) increases the allogamy of certain populations.

Morris (1882) was the first botanist to propose classification of cocoa populations into two groups: Criollo and Forastero. His classification was taken up by Pittier (1933), who designated each group as a different species: *T. leiocarpum* for Forastero and *T. cacao* for Criollo. However, all cocoa populations are inter-fertile, which in fact justifies the designation of a single species covering all wild and cultivated cocoa populations. Cuatrecasas (1964) proposed two sub-species: *T. cacao* subsp. *cacao* for Criollo and *T. cacao* subsp. *sphaerocarpum* for Forastero. A third group, Trinitario, contains hybrids between these two sub-species. This overall classification into two morpho-geographic groups, Criollo and Forastero, has been and is still in widespread use.

Classification of cocoa is difficult as it is affected by the history of cocoa domestication and by the substantial genetic mixing that has occurred, mainly over the last three centuries. The classifications proposed for the species *T. cacao* have therefore never been fully satisfactory. For example, according to some authors (Cheesman 1944; Soria 1970a and b) Nacional is an Upper Amazon Forastero, while for Enríquez (1993), some of its technological characteristics make it resemble a Criollo type.

Numerous hypotheses have also been put forward about the origin of the Criollo group (Cheesman 1944; Mora Urpi 1958; Cuatrecasas 1964; Purseglove 1968, Whitkus *et al.* 1998). The most widely held are those of Cheesman and Cuatrecasas. Based on Vavilov's principle, Cheesman (1944) considered the Upper Amazon as the centre of origin of Criollo and Forastero, given that it is in this region that the greatest morphological diversity is observed. Cheesman suggested that the spread of Criollo throughout Central America began from a small population in the upper reaches of the Amazon, which may have crossed the Andes with the help of man, and then formed differentiated populations as it spread. Cuatrecasas (1964), on the other hand, suggested that the species was indigenous from the Amazon region to Mexico.

Cuatrecasas backed up his hypotheses with observations of supposedly wild cocoa trees in the Lacandona forest near Chiapas, Mexico (Cuatrecasas 1964).

Study of the genetic structure of T. cacao

Many authors have participated in genetic diversity studies of *T. cacao* with morphological, enzymatic or molecular markers (for a recent review see Lanaud *et al.* 1999b). We report here some of the main results that have a direct bearing on cocoa genetic improvement. We firstly report on the level of heterozygosity as observed with isozymes, RFLP and microsatellite markers in the CIRAD laboratory at Montpellier.

Degree of heterozygosity of cocoa accessions
The data reported in Annex 1 are derived from the following sources: isozymes studies carried out by Lanaud (1987), RFLP studies carried out by Laurent *et al.* (1994) and by Risterucci, Motamayor, Raboin and Lanaud (unpublished data), and microsatellite studies carried out by Motamayor (also unpublished data).

The hybrid forms between Criollo and Forastero are called 'Trinitario" in Annex 1 even if they correspond to "modern Criollo" varieties that correspond in fact to ancient Criollo more or less introgressed by Forastero genes as demonstrated by Motamayor *et al.* (2000a and b).

The results show that most of Trinitario clones (*e.g.* UF, ICS, UIT) are very heterozygous, which is in agreement with their hybrid origin. Some other populations displayed a higher degree of homozygosity, for instance wild Forastero from French Guiana (GU), Amelonado and Catongo Forastero (C361) varieties and certain Criollo clones (LAN, COL, Guasare, POR, PSL), corresponding to ancient cultivars. Certain Upper Amazon Forastero types also appeared to have a relatively high degree of homozygosity, for instance the EBC clones collected in Colombia, certain Ecuadorian LCTEEN clones and SCA 6.

These results are very valuable to cocoa breeders since they can be used to determine the clones most likely to create uniform hybrid progenies or to determine homozygous genotypes belonging to different genetic groups which could be crossed to exploit possible hybrid vigour.

The origin and diversity of Nacional, Criollo and Trinitario varieties
Criollo and Trinitario varieties. The origin and diversity of Criollo and Trinitario have been studied by Motamayor *et al.* (2000a and b). For this study, plant material was collected from the oldest plantings in Venezuela, irrespective of agronomic criteria, and in the Lacandona Forest, Mexico, near Maya archaeological sites where there are sub-spontaneous cocoa trees that probably descend from the cocoa trees grown by the Mayas. Samples were also taken in Yucatan. These representatives of pure Criollo varieties grown in the past have different pod shapes: oval with smooth surface, like those of Porcelana, or elongated with a very rough surface, like those of Pentagona. The analysis of this material was supplemented with that of so-called 'current' Criollo and Trinitario varieties obtained from representative collections in Venezuela, Mexico and Costa Rica.

The analyses revealed a very small proportion of polymorphic loci among the individuals of ancient Criollo varieties. Moreover, within the group, hardly any molecular differences were observed, despite the highly contrasting morphotypes collected from Mexico to Venezuela, such as the Venezuelan Porcelana, Pentagona and Guasare, and the Criollo from the Lacandona Forest in Mexico.

The Criollo clones taken from collections generally appeared to be much more heterozygous. These clones had been originally selected not only for bean quality characters but also for agronomic characteristics (vigour, production or disease resistance). A Factorial Correspondence Analysis showed that the diversity of current

Criollo overlapped with that of the Trinitario clones studied. The more vigorous Criollo types may therefore correspond to ancestral Criollo forms into which Forastero genes have been introgressed to varying degrees.

Furthermore, the origin of the Forastero parents at the origin of modern Criollo and Trinitario was analysed. Around 90% of modern Criollo and Trinitario types apparently result from hybridisation and subsequent introgression between two genetically uniform types: homozygous Lower Amazon Forastero on one side and homozygous ancient Criollo on the other side. This is why in most cases only the same two alleles are found on each locus in the modern Criollo/Trinitario hybrid groups. Genotypes belonging to these groups would therefore represent different levels of recombinations of the Criollo and Lower Amazon Forastero parental genomes.

Ecuadorian Nacional. Lerceteau *et al.* (1997) used RFLP markers to study the Ecuadorian Nacional types which are grown today. A highly homozygous Nacional type was identified in old plantings in south-eastern and north-eastern Ecuador. These trees probably represent the homozygous ancestor at the origin of all the current hybrid varieties, (also called 'Nacional' types in collections), that result from Trinitario introgressions into this ancestral type with its extremely limited genetic base.

The diversity of Forastero populations. The Forastero group comprises a large number of wild populations and cultivated varieties originating from South America, which are found from Ecuador to the Guyanas. It includes vigorous trees and numerous sources of disease resistance. Significant genetic variability has been identified among these populations (*e.g.* Pound 1938 and 1945; Allen and Lass 1983). Certain Upper Amazon populations or geographic groups, such as LCTEEN and IMC, seem to be the most variable (Sounigo *et al.* 1996, see also this Proceedings), and there is continuous variation between them. Substantial within-population diversity has also been detected inside these populations, particularly those from Ecuador. Russel *et al.* (1993) showed that within-population diversity was greater than between population diversity for three Peruvian and Ecuadorian populations (IMC, PA, LCTEEN). Using enzymatic markers, the GU types from French Guiana, on the other hand, do not seem to vary much and have a relatively high level of homozygosity (Lanaud 1987) although significant morphological diversity has been observed in terms of pod shape (Lachenaud and Sallée 1993).

However, it is difficult to compare the degree of diversity among these different populations. In effect, not all the populations were sampled or represented in the same way. The surveys made by Allen in Ecuador were not based on any strict criteria and covered a very large area in which material was taken from a large number of trees. Pound's Peruvian clone samples, on the contrary, were taken for a precise purpose: witches' broom resistance. The material, which was taken from a limited number of trees is, therefore, not necessarily representative of the genetic diversity found in such area. Likewise, there was little material from clones from Colombia or from the Brazilian middle or upper Amazon in the material collected by Pound. Despite these often very biased samples, the genetic diversity (morphological, agronomical and by markers) observed was consistently substantial and greater than that found among the populations sampled in French Guiana or along the Orinoco in Venezuela.

The specificity of certain populations. Several populations or varieties seem to be clearly differentiated from the other morphogeographic groups identified for the species:

- French Guianan Forastero (GU clones) differ clearly from other Forastero populations for several molecular markers while their chloroplastic DNA is similar to that of most Forasteros. However, their rDNA is also original compared to that of all the other cocoa populations, with three types of unit per genome, and two units (9 and 12) that are not found in other populations (Laurent et al., 1993b). This originality was also found in RAPD studies by Sounigo *et al.* (1996) and by Lerceteau *et al.* (1997). In RFLP studies, they seemed to be more closely related to certain Upper Amazon Forastero than to Lower Amazon cultivated forms. However, the RAPD study made by N'Goran *et al.* (1994), which revealed different RAPD bands to those found by Lerceteau *et al.* (1997), showed Guianan cocoa trees to be better related similar to certain trees found in Brazil.

- The distinctiveness of the clones of the Ecuadorian pure Nacional varieties in relation to the other populations of the species was observed by Lerceteau *et al.* (1997), who thus also demonstrated their dissimilarity to Criollo.
- Several analyses have also shown the Criollos to form a distinct group (Laurent *et al.* 1993a, 1993b and 1994), particularly those corresponding to the populations cultivated in the past (Motamayor *et al.* 2000a). Analyses of genome size, using flow cytometry, have also shown that the Criollo genome size is smaller than that of Forastero (Lanaud *et al.*, unpublished data). Despite this marked difference, the genetic difference between Criollo with regard to certain Colombian and Ecuadorian accessions are as large as the latter accessions in relation to other Forastero populations (*e.g.* French Guianan or Peruvian populations), which would be in agreement with a South American origin of ancient Criollo (Motamayor *et al.* 2000a).

The narrow genetic base of the cocoa trees currently grown and used in improvement programmes. Genetic marker studies have shown the extremely narrow genetic basis of the Criollo, Trinitario, Nacional and Amelonado varieties, which account for almost all the traditional cocoa trees grown world-wide. From 1950 onwards, the Upper Amazon Forastero types collected by Pound started to be incorporated into cocoa improvement programmes. However, only a small part of the genetic diversity of the Pound collections has so far been used. In effect, it was somewhat by accident that some of them were distributed to a large number of producing countries (Lockwood and End 1993). Pods from nine of these clones, produced by Posnette in 1944 in an experiment on incompatibility designed for students, were sent to Ghana. The progenies were then spread throughout West Africa and later to Malaysia. Genetic improvement programmes have largely been, and continue to be, based on this Upper Amazon Forastero material. The material was generally hybridised with local Amelonado or Trinitario material, and later inter-Amazon crosses were also made. It is concluded therefore that only a small share of the genetic diversity of the species has been exploited, in terms of both traditional varieties and breeding programmes.

Consequences for cocoa genetic improvement

The first conclusion for cocoa breeding is that there is a large scope to increase the genetic bases for cocoa breeding. Certain Forastero types, such as GU clones, Ecuadorian LCTEEN clones and Colombian EBC clones have not yet been used for breeding purposes. Moreover, these genetic diversity analyses have also demonstrated the significant diversity of certain Upper Amazon populations, despite the fact that some samples were small or collected with precise criteria, such as the surveys made by Pound. This means that surveys of wild material should be continued in certain Upper Amazon regions such as Peru or Colombia, where there is substantial diversity that has not yet been sampled to any real extent.

Modern Criollo/Trinitario type varieties apparently result primarily from hybridization between two or three homozygous genotypes, and likewise, Nacional varieties apparently derive from a very small number of genotypes. This situation opens up a wide range of possibilities for improving these varieties, which produce an aromatic cocoa highly sought after for fine chocolate production. They could be improved for certain traits (like yielding capacity and precocity) by using existing or new hybrid combinations, with other genetic groups, selecting for favourable recombinants (*e.g.* combining good quality with good yield and disease resistance).

The possibilities for exploiting new types of hybrids are not limited to the improvement of Criollo or Nacional varieties, but are open to all cocoa breeding populations including hybrids between different Forastero populations. The hybrid vigour observed so far in many breeding programmes between Upper Amazon Forastero from Peru and Lower Amazon Forastero or Criollo could also exist, or be even more important, in many other hybrid combinations which have not yet been tested.

The new insights into the genetic structure of cocoa also have significant consequences for the choice and management of populations used in reciprocal recurrent selection strategies. In effect, sufficient genetic variability has to be maintained in the genetically different base populations to enable continuous genetic progress.

The narrow genetic base of the cocoa trees currently grown or being used for breeding purposes also favours exploitation of linkage disequilibria that may have been maintained between molecular markers and interesting traits during the genome evolution process. This phenomenon could enable greater use of the data acquired on the genome. For instance, in the case of the current Trinitario/Criollo, which have a very small number of parental genotypes, there have been very few generations of recombinations (probably six or seven at the most) between the first hybrids and current varieties. The close genetic linkages detected in some Trinitario clones between certain markers and genes of interest (Lanaud *et al.* 1999a; Lanaud *et al.* 2000; Clément *et al.* 2000; Paulin *et al.* 2000) may have been maintained for most of this population. If this is the case, this will allow greater screening possibilities and exploitation of the Criollo/Trinitario group using the markers close to those genes.

As explained above, this situation could be similar for the "new" Nacional varieties, *i.e.* the "pure" Nacional varieties which have received genes from certain Trinitario types. The small number of generations of recombinations has probably resulted in the maintenance of most of the close genetic linkages between markers and traits of interest, and should again enable screening of the varieties using those markers.

However, optimum use of the genetic resources of the species means clearly characterising all available accessions for morphological, agronomic, molecular, technological and sensorial traits. This comprehensive evaluation is highly complex but could be carried out firstly on a limited sample, as representative as possible of the diversity of the species using all available information (geographic, molecular and also morphological data).

One promising way for the future, with respect to a complete evaluation of cocoa genetic resources in terms of traits of interest, involves identification of the genes involved in the expression of those characters. This approach could be based on genome mapping, positional cloning and searching for candidate genes and would be associated with the use of high scale genome analyses. It would then be both easy and quick to look at the allele variations of the target gene within the species, identify original types and monitor the introgression of the character during breeding operations using a marker associated to the gene. This approach would thus facilitate the true exploitation of genetic diversity.

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Annex 1. Heterozygosity levels revealed by Isozyme (Lanaud 1987), RFLP (Laurent et al. 1994; Risterucci, Motamayor, Raboin and Lanaud, non published data), or microsatellite markers (Motamayor, non published data) in 412 wild and cultivated genotypes

Clone	Origin of selection	Iso-zymes Hetero	Iso-zymes Total	RFLP Hetero	RFLP Total	Micro-sat Hetero	Micro-sat Total	Collection	Comments
ACT2-11	Trinidad			6	29			CNRA	Trinitario
ACU85	Ghana	4	9	14	26			CNRA	Trinitario introduced from Venezuela
Aguacarte B	Belize					1	16	CRU	
ALV1	Aragua/Ven			11	33				Chuao/Trinitario
ALV4	Aragua/Ven			11	33				Chuao/Trinitario
ALV-0	Aragua/Ven			10	33				Chuao/Trinitario
Amazon2-1	Peru			8	33	5	16		Loreto
Amazon 15-15	Peru			3	19			CNRA	Loreto
AT5	Chuao/Ven			11	33				Chuao/Trinitario
Atelier	Nicaragua					8	15		Amelonado
BAN1	Tabasco/Mex			14	25			INIFAP, Finca El Danubio	Trinitario
BC3	Belize			0	25	1	16	CRU	Criollo/BC3D+BC3F
BEN1	Merida/Ven			0	25				Criollo/Zea
BEN2	Merida/Ven			0	25	0	16		Criollo/Zea
BEN5	Merida/Ven			0	24				Criollo/ZeaZea
Cacao 1	Yucatan/Mex			0	25	0	16		Criollo/Chechmil, Yucatan
Cacao 2	Yucatan/Mex			0	25	0	16		Criollo/Chechmil, Yucatan
Cacao 3	Yucatan/Mex			0	25	0	16		Criollo/Chechmil, Yucatan
CAS5	Chiapas/Mex			0	25				Criollo, Lacandona rainforest
BO204	Venezuela			0	2			FONAIAP	Bocadillos
BOC210	Venezuela			4	24			FONAIAP	Bocadillos
CATA201	Aragua/Ven			2	7			FONAIAP	Cata
CATA209	Aragua/Ven			14	33			FONAIAP	Trinitario/Cata
CATA211	Aragua/Ven			14	29			FONAIAP	Trinitario/Cata
CC10	Costa Rica			4	15			CNRA	dl Matina? or Matina x Trinitario
CC39	Costa Rica			14	30			CNRA	dl UF668
CEC1	Aragua/Ven			6	20				Trinitario/Cuyagua
CEC2	Aragua/Ven			16	33				Trinitario/Cuyagua
CHA5	Chiapas/Mex			0	25	0	16		Criollo, Lacandona rainforest
CHA13	Chiapas/Mex			0	25				Criollo, Lacandona rainforest
CHA18	Chiapas/Mex			0	25	0	16		Criollo, Lacandona rainforest
CHA20	Chiapas/Mex			0	25	0	16	INIFAP, Finca El Danubio	Criollo, Lacandona rainforest
CHO28	Aragua/Ven			11	33			FONAIAP	Trinitario
CHO31	Aragua/Ven			14	33			FONAIAP	Trinitario
CHO36	Aragua/Ven			13	33			FONAIAP	Trinitario
CHO41	Aragua/Ven			12	33			FONAIAP	Trinitario
CHO42	Aragua/Ven			24	33	16	16	FONAIAP	Trinitario

CHO94	Aragua/Ven			10	33			FONAIAP	Trinitario
CHO131	Aragua/Ven			6	33			FONAIAP	Trinitario
CHO174	Aragua/Ven			13	33			FONAIAP	Trinitario
CHOS201/12	Aragua/Ven			11	32			FONAIAP	Trinitario
CHOS205/34	Aragua/Ven			12	33			FONAIAP	Trinitario
CHOS205/37	Aragua/Ven			13	33			FONAIAP	Trinitario
CHOS217/18	Aragua/Ven			10	32			FONAIAP	Trinitario
CHUAO24	Aragua/Ven			10	28			FONAIAP	Trinitario
CHUAO49	Aragua/Ven			3	20			FONAIAP	Trinitario
CHUAO120	Aragua/Ven			16	33	7	16	FONAIAP	Trinitario
CHUAO202	Aragua/Ven			15	33			FONAIAP	Trinitario
CHUAO211	Aragua/Ven			4	14			FONAIAP	Trinitario
CNS22	Mexico			4	15			CATIE	Trinitario
CNS23	Mexico			1	6			CATIE	Trinitario
COL11	Magdalena Colombia			0	25			Centro de Investigacion Caribia	Criollo
COL2	Magdalena Colombia			0	25			Centro de Investigacion Caribia	Criollo
COL3	Magdalena Colombia			0	25			Centro de Investigacion Caribia	Criollo
COL4	Magdalena Colombia			0	25	0	16	Centro de Investigacion Caribia	Criollo
COL5	Magdalena Colombia			0	25			Centro de Investigacion Caribia	Criollo
COL7	Magdalena Colombia			0	25			Centro de Investigacion Caribia	Criollo
COL8	Magdalena Colombia			0	25			Centro de Investigacion Caribia	Criollo
COL9	Magdalena Colombia			8	25			Centro de Investigacion Caribia	Criollo
CL10	Magdalena Colombia			0	25	0	16	Centro de Investigacion Caribia	Criollo
Comun tipico	Brazil			3	21			CATIE	Amelonado selection
CPC1	Aragua/Ven			17	33			FONAIAP	Trinitario
Criollo 5	Nicaragua			6	25	8	16	CATIE	Trinitario
Criollo 12	Panama			11	24	7	16	CATIE	Trinitario
Criollo 37	Nicaragua			6	25	3	16	CATIE	Trinitario
Criollo 216	Costa Rica					7	15	CATIE	Trinitario
CRP2	Aragua/Ven			15	33			FONAIAP	Trinitario/Cuyagua
CS1	Sucre/Ven			11	33				Trinitario
CS2	Sucre/Ven			12	33				Trinitario
CS3	Sucre/Ven			13	32				Trinitario
CS5	Sucre/Ven			18	33				Trinitario
CS7	Sucre/Ven			8	33				Trinitario
CS9	Sucre/Ven			7	33				Trinitario
CUM209	Cumboto/Ven			8	9			FONAIAP	Trinitario
CUM214	Cumboto/Ven			1	9			FONAIAP	Trinitario
DR1	Indonesia			10	27	11	16	CNRA	Java Trinitario
E1J92/70	Ghana	2	8	16	28			CNRA	local Trinitario
EBC5	Colombia			0	28	9	16	CIRAD/MPL	
EBC6	Colombia			3	29	3	16	CIRAD/MPL	
EBC10	Colombia			3	29	6	16	CIRAD/MPL	
ECH1	Tabasco/Mex			19	25				Trinitario

ECH2	Tabasco/Mex			19	25	15	16		Trinitario
ECNR	ecuador			3	16			CRU	Ecuador Cacao Nacional Refractario
EET59	ecuador			4	18			CEPEC	San Javier cacao nacional
EQX27	ecuador			12	23			CNRA	EET59XEET62
EQX94	ecuador			9	26			CNRA	
EQX100	ecuador			2	4			CNRA	
EQX107	ecuador			4	15			CNRA	
ERJOH1	Brazil			2	20			CEPEC	Caco
ERJOH2	Brazil			2	16			CEPEC	Purus
ERJOH3	Brazil			4	17			CEPEC	Envira
ERJOH4	Brazil			2	9			CEPEC	Jaranca
ERJOH5	Brazil			2	20			CEPEC	Jurua
ERJOH6	Brazil			2	9			CEPEC	Curuça
ERJOH7	Brazil			4	14			CEPEC	Içа
ERJOH8	Brazil			8	19			CEPEC	Solimoes
ERJOH9	Brazil			0	6			CEPEC	Branco
ERJOH10	Brazil			0	6			CEPEC	Balbina
ERJOH11	Brazil			7	21			CEPEC	Alenquer
ERJOH12	Brazil			8	30	3	16	CEPEC	Ariquemes
ERJOH13	Brazil			7	15			CEPEC	Altamira
ERJOH14	Brazil			3	11			CEPEC	Bonevides
ERJOH15	Brazil			5	25	5	14	CEPEC	Japira
G8	Indonesia	3	8	8	24			Trinitario/CNRA	Trinitario
G23	Indonesia			6	28	8	16	Trinitario/CATIE	Trinitario
GAL2	Zulia/Ven			3	25				Trinitario
GS29	Granada	6	9	6	13			Trinitario/CNRA	Trinitario
GS36	Granada	6	9	17	29			Trinitario/CNRA	Trinitario
GU144	Guyane Fr.			1	29	4	16	CIRAD/MPL	wild Cam. 7
GU154	Guyane Fr.			0	30	0	16	CIRAD/MPL	wildCam. 8
GU346	Guyane Fr.			2	30	4	16	CIRAD/MPL	wildCam. 13
GU349	Guyane Fr.			1	29	0	16	CIRAD/MPL	wildCam. 3
Guasare1	Guasare/Ven			1	33			Criollo	Criollo
Guasare2	Guasare/Ven			1	33			Criollo	Criollo
Guasare3	Guasare/Ven			1	33			Criollo	Criollo
Habillal1	Michoacan/Mex					0	16		Criollo
HE2	Tachira/Ven			11	33				Trinitario
HE3	Tachira/Ven			14	33				Trinitario
HE4	Tachira/Ven			2	33	0	16		Criollo
HE5	Tachira/Ven			8	33				Trinitario
HE6	Tachira/Ven			12	33				Trinitario
HE201	Tachira/Ven			12	33				Trinitario
Hernandez 212	Tachira/Ven			4	28			FONAIAP	Trinitario
I059	Tabasco/Mex			19	25			INIFAP, Finca El Danubio	Trinitario
ICS1	Trinidad	3	9					CNRA	Trinitario
ICS6	Trinidad	3	9	12	30			CNRA	Trinitario
ICS16	Trinidad	4	8	11	29	10	16	CNRA	Trinitario

ICS39	Nicaragua	5	9	12	23			CNRA	Trinitario
ICS40	Nicaragua	6	9	16	27	14	15	CNRA	Trinitario
ICS46	Trinidad	5	9	17	30			CNRA	Trinitario
ICS48	Nicaragua			18	29			CRU	Trinitario
ICS53	Trinidad	3	9	11	30	8	14	CNRA	Trinitario
ICS60	Nicaragua	5	9	25	38	15	16	CNRA	Trinitario
ICS75	Trinidad	5	9	14	28			CNRA	Trinitario
ICS84	Trinidad	4	9	15	30			CNRA	Trinitario
ICS89	Trinidad	2	8	18	29	15	15	CNRA	Trinitario
ICS95	Trinidad	3	9	7	12	13	16	CEPEC	Trinitario
ICS98	Trinidad			9	17			CEPEC	Trinitario
ICS100	Nicaragua	2	8	14	39	6	16	CNRA	Trinitario
IFC1	Côte d'Ivoire	0	9	3	23			CNRA	Amenolado local selection
IFC2	Côte d'Ivoire	0	9	0	27			CNRA	Amenolado local selection
IFC4	Côte d'Ivoire	1	9	9	29	7	16	CNRA	Trinitario local selection
IFC5	Côte d'Ivoire	2	9	7	30	6	16	CNRA	Trinitario local selection
IFC6	Côte d' Ivoire	3	9	10	28			CNRA	Trinitario local selection
IFC7	Côte d' Ivoire	3	9	6	30			CNRA	Trinitario local selection
IFC11	Côte d' Ivoire	2	9	10	30	6	16	CNRA	Trinitario local selection
IFC15	Côte d'Ivoire	3	9	8	30			CNRA	Trinitario local selection
IFC19	Côte d' Ivoire	3	9	11	30	7	16	CNRA	Trinitario local selection
IFC361 (Catongo)	Brazil	0	9	0	30			CNRA	Bahia selection
IFC413	Côte d' Ivoire			10	29			CNRA	dIR15
IFC414	Ghana			8	26			CNRA	dl IFC307
IFC420	Côte d' Ivoire			6	27			CNRA	dIR15
IFC422	Côte d' Ivoire			0	29			CNRA	dIE1
IFC 1212	Côte d' Ivoire			7	25			CNRA	PA150xIFC5
IFC 1213	Côte d' Ivoire			8	25			CNRA	PA150xIFC6
IMC5	Peru	3	9	9	27	8	15	CNRA	
IMC6	Peru	4	9					CNRA	
IMC14	Peru			7	20			CRU	
IMC23	Peru	3	9	9	31			CNRA	
IMC31	Peru	3	9	5	18			CNRA	
IMC47	Peru			9	31	10	15	CIRAD/MPL	
IM57	Peru	5	9	5	16			CNRA	
IMC67	Peru	3	9	9	29			CNRA	
IMC78	Peru	2	8	6	22			CNRA	
IMC85	Peru			7	20			CRU	
IMC105	Peru			11	26			CRU	
JS201	Yaracuy/Ven			6	11			FONAIAP	Trinitario/Jobal Zaragoza
JS202	Yaracuy/Ven			12	29			FONAIAP	Trinitario/Jobal Zaragoza
JS206	Yaracuy/Ven			14	28			FONAIAP	Trinitario/Jobal Zaragoza
JS210	Yaracuy/Ven			14	28			FONAIAP	Trinitario/Jobal Zaragoza
JS211/21	Yaracuy/Ven			14	33			FONAIAP	Trinitario/Jobal Zaragoza
K5 (IFC305)	Ghana	1	9	7	30			CNRA	Trinitario local selection (axil spot)
LaEsmida	Mexico			8	30			CATIE	Trinitario

LAN1	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LAN2	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LAN3	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LAN4	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LAN6	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LAN7	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LAN8	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LAN9	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA10	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA11	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA12	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA13	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA14	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LA16	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA17	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LA18	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA19	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LA21	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LA22	Chiapas/Mex	0	25			INIFAP, Finca El Danubio	Criollo, Lacandona rainforest
LA23	Chiapas/Mex	0	25			INIFAP, Finca El Danubio	Criollo, Lacandona rainforest
LA24	Chiapas/Mex			0	16	INIFAP, Finca El Danubio	Criollo, Lacandona rainforest
LA26	Chiapas/Mex	0	25			INIFAP, Finca El Danubio	Criollo, Lacandona rainforest
LA27	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LAN28	Chiapas/Mex	0	25	0	16		Criollo, Lacandona rainforest
LAN29	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LAN30	Chiapas/Mex	0	25				Criollo, Lacandona rainforest
LAF1	Costa Rica	13	28			CATIE	Trinitario
LAF2	Costa Rica	8	23			CNRA	Trinitario
LAF3	Costa Rica	3	16			CATIE	Trinitario
LAFI/7	Samoa	7	24				Trinitario
LCTEEN37	Ecuador	5	30	5	16	CIRAD/MPL	Napo
LCTEEN84	Ecuador	2	9			CRU	Zamora
LCTEEN109	Ecuador	0	2			CRU	Napo
LCTEEN127	Ecuador	1	17			CRU	
LCTEEN167	Ecuador	2	8			CIRAD/MPL	
LCTEEN202	Ecuador	1	10			CRU	Napo
LCTEEN295	Ecuador	3	11			CRU	Morona
LCTEEN325	Ecuador	3	21			CRU	Napo
LCTEEN326	Ecuador	3	22			CRU	
LCTEEN355	Ecuador	2	30	7	16	CIRAD/MPL	Morona
LCTEEN371	Ecuador	1	3			CIRAD/MPL	Pastaza
LIB1	Nicaragua	0	25	0	16	INTA	Criollo
LIB2	Nicaragua	0	25	0	16	INTA	Criollo
LIB3	Nicaragua	0	25	0	16	INTA	Criollo
LIMON	Michoacan/Mex			0	16		Criollo
LMD1	Aragua/Ven	8	32			FONAIAP	Trinitario/Chuao

LMD4	Aragua/Ven			6	33			FONAIAP	Trinitario/Chuao
LMD5	Aragua/Ven			10	33			FONAIAP	Trinitario/Chuao
LPM2	Michoacan/Mex			13	25			Universidad de Chapingo	Trinitario
LPM3	Michoacan/Mex			14	25			Universidad de Chapingo	Trinitario
LPM4	Michoacan/Mex			11	25			Universidad de Chapingo	Trinitario
LPM6	Michoacan/Mex			12	25			Universidad de Chapingo	Trinitario
LV0	Aragua/Ven			11	33			FONAIAP	Trinitario/Chuao
LV1	Aragua/Ven			13	33			FONAIAP	Trinitario/Chuao
LV2	Aragua/Ven			12	32			FONAIAP	Trinitario/Chuao
LV3	Aragua/Ven			10	33			FONAIAP	Trinitario/Chuao
LV4	Aragua/Ven			8	33			FONAIAP	Trinitario/Chuao
LV6	Aragua/Ven			21	33			FONAIAP	Trinitario/Chuao
LV00	Aragua/Ven			7	33			FONAIAP	Trinitario/Chuao
LV13	Aragua/Ven			4	33			FONAIAP	Trinitario/Chuao
LV14	Aragua/Ven			12	33			FONAIAP	Trinitario/Chuao
MAT1-6	Costa Rica			0	30	0	16	CNRA	Matina
MAT1-9	Costa Rica			1	9			CNRA	Matina
MO9	Peru	3	9	8	30	6	16	CNRA	Morona
MO81	Peru	3	9	4	13			CNRA	Morona
MO98	Peru			9	27	9	14	CNRA	Morona
MOQ122	Ecuador			1	14			CRU	local selection
MOQ216	Ecuador			6	30			CNRA	local selection
MOQ413	Ecuador	2	8	2	8			CNRA	local selection
MOQ647	Ecuador	3	9	7	22			CNRA	local selection
MOQ663	Ecuador			1	13			CRU	local selection
MT1	Honduras/Guat			8	25			CATIE	
N38	Nigeria	1	9	0	14			CNRA	dl ICS93
NA2	Peru	4	9					CNRA	
NA27	Peru	4	9					CNRA	
NA32	Peru	4	9	5	23			CNRA	Nanay
NA33	Peru					8	15	CRU	Nanay
NA58	Peru	1	9					CNRA	
NA79	Peru	1	9	1	2			CNRA	Nanay
NA95	Peru	1	9					CNRA	
NA691	Peru	3	8					CNRA	
Nacional	Ecuador			11	27			CATIE	arriba flavor
NR1	Chuao/Ven			17	33				Trinitario
NOVC5	Tachira/Ven					0	16	FONAIAP	Criollo/Novillero
NV29	Tachira/Ven			8	25	10	15	FONAIAP	Trinitario/Novillero
OC60	Aragua/Ven			23	33			FONAIAP	Trinitario/Ocumare
OC61	Aragua/Ven			17	33			FONAIAP	Trinitario/Ocumare
OC61dl	Aragua/Ven			1	24			CIRAD/MPL	Trinitario/Ocumare
OC63	Aragua/Ven			14	32			FONAIAP	Trinitario/Ocumare
OC66	Aragua/Ven			17	33			FONAIAP	Trinitario/Ocumare
OC73	Aragua/Ven			14	33			FONAIAP	Trinitario/Ocumare
OC77	Aragua/Ven			9	29			FONAIAP	Trinitario/Ocumare

OS02	Chiapas/Mex			19	25				Trinitario/In a plantation
P4/9	Peru			3	26				
P1	Peru	1	8	1	29			CNRA	Nanay
P2	Peru	1	9	0	28	1	15	CNRA	Nanay
P 7	Peru	4	9	6	25			CNRA	
P13B	Peru	1	9					CNRA	
P16	Peru			8	28	8	15	CNRA	Nanay
P19A	Peru	5	9					CNRA	
P32A	Peru	1	9	1	25			CNRA	Nanay
PA4	Peru	0	9	0	1			CNRA	
PA7	Peru	4	9	5	19			CNRA	
PA13	Peru	2	7	14	39	9	16	CNRA	
PA20	Peru			4	11			CRU	
PA76	Peru			8	32	7	15	CRU	
PA107	Peru			8	31	7	16	CRU	
PA121	Peru	2	9	6	19			CNRA	
PA150	Peru	2	9	0	9			CNRA	
PA300	Peru			7	19			CRU	
Para	Brazil			1	23			CATIE	Bahia selection
PC1	Zulia/Ven			1	33				Criollo
Pentagona 16	Mexico			14	25	6	16	CATIE	Trinitario
Peres 2	Magdalena/Colomb			0	25	0	16		Criollo/Tayrona Park
POR	Zulia/Ven	6	8					CNRA	Trinitario
POB	Zulia/Ven	4	7	11	21			CNRA	Trinitario
POC	Zulia/Ven	5	8	5	16			CNRA	Trinitario
POR210	Zulia/Ven			3	15			FONAIAP	Trinitario
POR211	Zulia/Ven			3	11			FONAIAP	Trinitario
POR215/A	Zulia/Ven			1	33			FONAIAP	Criollo
POR215/B	Zulia/Ven			1	33			FONAIAP	Criollo
Porcelana3	Zulia/Ven			6	18			CATIE	Trinitario
Porcelana Rojo	Zulia/Ven			3	27			FONAIAP	Criollo
PR01	Zulia/Ven			11	25			FONAIAP	Trinitario/Porcelana Plantations
Providencia 201	Venezuela			5	22			FONAIAP	Trinitario
PSL1	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL2	Zulia/Ven			1	30				Criollo/Porcelana Plantations
PSL3	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL4	Zulia/Ven			1	31				Criollo/Porcelana Plantations
PSL5	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL6	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL7	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL8	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL9	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PSL10	Zulia/Ven			1	33				Criollo/Porcelana Plantations
PV2	Zulia/Ven			9	29			CATIE	Trinitario
PV4	Zulia/Ven			5	8			CATIE	Trinitario

PV6	Zulia/Ven			1	24			CATIE	
Q7	Ghana	1	7	3	27			CNRA	
RANCHITO1	Michoacan/Mex			0	25	0	16		Criollo
RIM8	Mexico			12	26			CATIE	Trinitario/type Soconusco
RIM15	Mexico	3	9	11	23			CATIE	Trinitario/type Soconusco
RIM19	Mexico			5	16			CATIE	Trinitario/type Soconusco
RM68	Mexico			13	24	6	16		Trinitario
RIM76,	Mexico			6	16			CATIE	Trinitario/type Soconusco
RIM105	Mexico			9	20			CATIE	Trinitario/type Soconusco
RIM113	Mexico			11	21	16	16	CATIE	Trinitario/type Soconusco
R189	Mexico			11	22	6	15		Trinitario
STAMARIA2	Michoacan/Mex			0	25				Criollo
S52	Sao Tomé	1	9	14	24			CNRA	Trinitario
S84	Ghana	0	9	7	33				Trinitario
SAL2	Merida/Ven			7	33				Amelonado
SAUCITO1	Michoacan/Mex			0	25				Criollo
SC5	Colombia			15	26			CATIE	
SC6	Colombia			1	26			CATIE	
SCA6	Ecuador	1	9	3	29	10	16	CNRA	Scavina
SCA9	Ecuador			9	38	6	14	CNRA	Scavina
SCA12	Ecuador			8	24			CNRA	Scavina
SF23	Côte d'Ivoire			11	25			CNRA	Amenolado local selection
SJU1	Guasare/Ven			0	25	0	16		Criollo/From Guasare region
SJU3	Guasare/Ven			0	25				Criollo/From Guasare region
SJU6	Guasare/Ven			0	25				Criollo/From Guasare region
SIAL42	Brazil			13	27			CATIE	Selections made from farms specially in the South of Bahia
SIAL70	Brazil			2	30	0	16	CATIE	Selections made from farms specially in the South of Bahia
SIAL325	Brazil			2	19			CATIE	Selections made from farms specially in the South of Bahia
SIC864	Brazil			1	30	0	15	CIRAD Montpellier	Selection from a Catongo population
SN10	Cameroun			11	25	7	16	IRAD	Trinitario local selection
SNK12	Cameroun	3	8	8	26			IRAD	Trinitario local selection
SN64	Cameroun			5	25			IRAD	Trinitario local selection
SNK109	Cameroun	3	8	5	22			IRAD	Trinitario local selection
SNK413	Cameroun			11	25			IRAD	Trinitario local selection
SNK625	Cameroun			6	25			IRAD	Trinitario local selection
SP1	Zulia/Ven			2	33	0	16	FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP2	Zulia/Ven			3	33	0	16	FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP3	Zulia/Ven			1	33			FONAIAP, EL Chama	Criollo/Porcelana Plantations
SP4	Zulia/Ven			2	33			FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP5	Zulia/Ven			1	32			FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP6	Zulia/Ven			1	32			FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP7	Zulia/Ven			1	33			FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP8	Zulia/Ven			1	32			FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations

SP9	Zulia/Ven			3	33			FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SP10	Zulia/Ven			1	32	0	16	FONAIAP, Estacion EL Chama	Criollo/Porcelana Plantations
SPA5	Colombia			5	14			CATIE	Oriente Ecuador
SPA11	Colombia			5	17			CATIE	Oriente Ecuador
SPA17	Colombia			5	16			CATIE	
SPEC54-2	Colombia			0	26			CNRA	
SPEC138-8	Colombia			14	29			CNRA	
SPEC160-9	Colombia			15	30			CNRA	
SPEC185-4	Colombia			2	25			CNRA	
ST1	Belize			0	25	0	16	CRU	Pool of ST1 progenies
STA1	Nicaragua					9	16		Amelonado
STA2	Nicaragua					10	15		Amelonado
T16/613	Ghana	1	9					CNRA	
T60/887	Ghana	2	7	8	20			CNRA	PA7xNA32
T63/967	Ghana			8	24			CNRA	Pa35xNa32
T79/416	Ghana	4	9	1	9			CNRA	NA32xPA7
T79/501	Ghana			4	11			CNRA	NA32xPA7
T85/799	Ghana	5	9	5	14			CNRA	IMC60xNA34
TAP12	Peru			5	32				Tapiche river
THCA	Chiapas/Mex			0	25				Criollo, Lacandona rainforest
T5	Yucatan/Mex			0	25				Tixcacaltuyub, Mexico
TJ1	Honduras/Guat			5	26			CATIE	Trinitario
T1077	Trinidad			14	24	12	15		
UF10	Costa Rica			15	26			CATIE	Trinitario
UF168	Panama			17	30	16	16	CATIE	Trinitario
UF221	Costa Rica	6	9	14	26			CNRA	Trinitario
UF296	Costa Rica			10	22			CEPEC	Trinitario
UF667	Costa Rica	6	9	16	29	13	13	CNRA	Trinitario
UF676	Costa Rica	6	8	17	29	14	14	CNRA	Trinitario
UIT1	Malaysia			16	19				Trinitario/Sabah
UIT2	Malaysia			17	21				Trinitario/Sabah
UIT3	Malaysia			18	21				Trinitario/Sabah
UIT4	Malaysia			17	20				Trinitario/Sabah
UIT5	Malaysia			24	33				Trinitario/Sabah
UPA134	Cameroun			9	25			IRAD	
UPA401	Côte d'Ivoire			5	18			CNRA	(IMC60xNA34)
UPA402	Côte d'Ivoire	0	8					CNRA	
UPA409	Côte d'Ivoire	0	6					CNRA	
UPA413	Côte d'Ivoire	4	8	6	24			CNRA	(IMC60xNA34)
UPA603	Côte d'Ivoire	1	8	6	24			CNRA	T79xT72 = (NA32xPA7)x(NA32xIMC60)
UPA608	Côte d'Ivoire	2	6	3	10			CNRA	T79xT72 = (NA32xPA7)x(NA32xIMC60)
UPA620	Côte d'Ivoire	2	8	0	4			CNRA	T79xT72 = (NA32xPA7)x(NA32xIMC60)
VENC1	Venezuela			1	22			CIRAD/MPL	
VENC4	Venezuela			5	38	3	15	CIRAD/MPL	
VENC5	Venezuela			1	25			CIRAD/MPL	wild

VENC11	Venezuela			1	29	2	15	CIRAD/MPL	wild
VENC15	Venezuela			1	19			CIRAD/MPL	Forastero/orinoco
VENC20	Venezuela			0	23	0	15	CIRAD/MPL	Forastero/orinoco
VENC31	Venezuela			0	3			CIRAD/MPL	Forastero/orinoco
W41	Ghana	3	9					CNRA	
WA40	Java	5	9	0	28			CNRA	G8xDR8 ou DR1xDR32
Y1	Yucatan/Mex			0	25	0	16	INIFAP, Finca El Danubio	Criollo/Yaxcaba, Mexico
Y2	Yucatan/Mex			0	25	0	16	INIFAP, Finca El Danubio	Criollo/Yaxcaba, Mexico
Y3	Yucatan/Mex			0	25	0	16	INIFAP, Finca El Danubio	Criollo/Yaxcaba, Mexico
ZEA1	Merida/Ven			2	33			FONAIAP	Criollo
ZEA2	Merida/Ven			2	33			FONAIAP	Criollo
ZEA3	Merida/Ven			4	33			FONAIAP	Criollo
ZEA4	Merida/Ven			2	33	0	16	FONAIAP	Criollo
ZEA206	Merida/Ven			3	27			FONAIAP	Criollo

Key to the terms used:

- 'Isozyme hetero', 'RFLP hetero' or 'microsat hetero' = number of heterozygous loci revealed by isozyme, RFLP or microsatellite markers respectively.
- 'Isozyme total', 'RFLP total' or 'microsatellite total' = total number of isozyme, RFLP or microsatellite loci studied.

'Mex' = Mexico, 'Ven' = Venezuela, 'Colomb' = Colombia, 'Guyane FR' = French Guiana and 'Guat' = Guatemala